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DOES INTENSITY OF PHYSICAL ACTIVITY MODERATE INTER-RELATIONSHIPS AMONG FITNESS, PHYSICAL ACTIVITY AND HEALTH?

Terina M. MCALEESE[1], Lukas I. DREYER[1], Sonja DREYER[1] & Scott DUNCAN[2]
[1] *Universal College of Learning, Palmerston North, Manawatu, New Zealand*
[2] *Auckland University of Technology, Auckland, New Zealand*

ABSTRACT

The aim of this study was to determine whether perceived intensity of training moderates the physical activity-health, physical activity-fitness, and fitness-health relationships. The participants (N=237) from eight different companies were assessed for participation in physical activity, cardiovascular fitness and health. Fasting blood samples, resting heart rate and blood pressure, as well as body composition measurements were taken. The YMCA three-stage cycle ergometer test was conducted and the ACSM (2010) metabolic and multi-stage equations were utilised to calculate functional capacity in METs. Physical activity was measured with two questionnaires (Sharkey index and Baecke questionnaire), that allows for comparison of relative intensity of training with absolute physical activity scores. ANCOVA and Stepwise Multiple Regression analyses were used to assess the relationships of perceived intensity of training and functional capacity with various measures of health. Perceived intensity of training had marginally moderating effects on physical activity-health (F=1.135; Eta^2=1.7% versus F=0.228; Eta^2=0.4%) and the physical activity-fitness (F=8.5; Eta^2=8.5% versus F=2.35; Eta^2=2.5%) relationships. Cardiovascular fitness (MET) contributed 9.5% (p=0.002) to the variance of a composite health score in comparison to the non-significant (p=0.470), 1.2% contribution of intensity of training.

Key words: Perceived intensity of training; Cardiovascular fitness; Coronary risk; Metabolic syndrome; Health.

INTRODUCTION

More than 20 years ago, the American Health Association (AHA) identified physical inactivity as the fourth primary risk factor for Coronary Artery Disease (CAD) (Fletcher *et al*., 1996). However, there is on-going debate concerning the measurement of physical activity (PA), and the prescription dose to optimise health benefits. Williams (2001) ignited the prescription debate with a thought-provoking meta-analysis, concluding that the formalisation of the 1996 ACSM prescription guidelines ensued from inappropriate use of cardiovascular fitness studies. The consequential guidelines demote the importance of cardiovascular fitness, while overstating the public health benefits of moderate amounts of PA, according to Williams (2001).

It is a problem developed due to the use of fitness as a 'surrogate' for PA. A practice historically based on the assumption that fitness reflects PA patterns. Fitness measurements are considered more accurate, while measurement of PA continues to be an elusive concept.

Various PA questionnaires have been developed and tested for validity and reliability over the years (Helmerhorst *et al*., 2012; Scott *et al*., 2013). The majority correlate relatively poorly (r=0.27-0.56) with measures of cardiovascular fitness (Williams, 2001; Shephard, 2002; Warren *et al*., 2010; DaFina *et al*., 2015). Most of these questionnaires are absolute scales that calibrate the intensity of activity based on effort required by healthy, young to middle-aged adults. The International Physical Activity Questionnaire (IPAQ), generally considered the gold-standard measuring tool, for instance, express PA in absolute terms as MET minutes per week. The IPAQ calculate MET minutes per week by multiplying fixed MET-values for walking (3.3 MET), moderate (4.0 MET) and vigorous activity (8.0 MET) with minutes (duration) and days (frequency) of activity. This process ignores the fact that relative intensity of effort required for the same activity changes as one moves across the physical fitness spectrum. An increasing amount of studies is starting to emphasise the importance of relative intensity of training in terms of health, fitness and measuring PA (Swain, 2005; Franklin, 2007; Kemi & Wisløff, 2010; Rhen *et al*., 2013; DeFina *et al*., 2015; Ramos *et al*., 2015).

Lee *et al*. (2003), for example, found an inverse relationship between relative perceived intensity of PA and Coronary Heart Disease (CHD) risk in older men. The fact that this applied even among those not satisfying current PA recommendations, endorse the importance of relative perceived intensity of training.

RESEARCH PROBLEM AND PURPOSE

The current study proposes that the amalgamation of perceived intensity, duration and frequency into one overall absolute PA score impact negatively on the prediction (cardiovascular fitness and health) qualities of PA questionnaires. The researchers of the current study postulate that when measuring PA, using a relative scale, like the Borg Perceived Exertion and Pain Scale, to gauge the intensity of activity would be more appropriate than absolute scales. Surprisingly, there is a limited amount of published data examining the associations of relative measures of perceived intensity of training with cardiovascular fitness and measures of health.

This study consequently focused on relative perceived intensity of exercise as moderator of health and fitness. Relative and absolute measures of PA were used to study the inter-relationships between PA, physical fitness and health. The aims of this study were:

1. to determine whether relative perceived intensity of training relates better with measures of health than absolute PA scores;
2. to determine whether relative perceived intensity shows better relationships with measures of cardiovascular fitness than absolute measures of PA; and
3. to determine whether relative perceived intensity negates or strengthens the cardiovascular fitness-health relationship.

METHODOLOGY

The data were collected as part of the iWorkWell project, which was conducted by Sport Manawatu on behalf of the Manawatu Mid-Central District Health Board. Participation was voluntary. Two hundred and thirty-seven (N=237) participants from 8 different companies were tested. The mean age of the sample was 39.5 years. Approval was obtained from the Central Regional Ethics Committee (CEN11/04/024).

Procedures and data collection

All testing/data sampling was done at the Exercise Science Laboratory of the Universal College of Learning in Palmerston North, New Zealand.

Anthropometrical measures

Weight was recorded with the shoes and as much other clothes removed as possible. Percentage body fat was obtained using the procedure of 6 skin folds (triceps, subscapula, supra-iliac, abdominal, thigh and medial calf), according to the guidelines of the ISAK (International Society for the Advancement of Kinanthropometry) (2001). A level III Anthropometrist conducted all the measurements.

Biochemical measures

Total cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), triglycerides, glucose and the total cholesterol/HDL-ratio (TC/HDL-ratio), were assessed at a registered biochemistry laboratory. Respondents were scheduled for testing over 2 days and were asked to fast for 8 hours prior to blood testing. Non-HDL (TC-HDL), TC/HDL-ratio and Trig/HDL-ratio were calculated.

Physiological variables

The physiological variables that were measured included resting heart rate (RHR) and resting blood pressure (RBP). RBP was measured 3 times after the subjects had rested for 5 minutes in the supine position in a quiet room and the lowest reading was recorded. RHR was measured for a full minute with a stopwatch and stethoscope. Heartbeats were counted and correlated with the readings of a polar heart rate monitor. This was taken after the resting blood pressure measurements.

Coronary Risk Index (CRI)

Coronary risk was assessed using a coronary risk index reflecting the 14 most common or typical risk factors for CAD and utilising a Likert-scale format based on levels of risk (Bjurstrom & Alexiou, 1978).

Illness Rating Scale

Symptomatology was measured through the Seriousness of Illness Rating Scale (IRS) (Wyler *et al*., 1968), a self-reported checklist of 126 commonly recognised physical and mental symptoms and diseases. In the development of this instrument, a general severity weight for each disorder was obtained by asking a large sample of physicians and laypersons to rate each of them. This carefully developed scale of seriousness of illness has served as a tool used frequently in stress and illness studies (Schroeder & Costa, 1984).

Metabolic syndrome score

The ATP III criteria for diagnosis of metabolic syndrome include waist circumference (males >102cm; females >88cm), triglycerides (≥1.70mmol.l^{-1}), HDL-cholesterol (males <1.03mmol.l-1; females <1.30mmol.l-1), systolic blood pressure (≥130mmHg), diastolic blood pressure (≥90mmHg) and fasting glucose (≥6.0mmol.l-1) (Grundy *et al*., 2004). For the purpose of this study the above-mentioned values exceeding the stipulated cut-offs were added into a cumulative metabolic syndrome score. Some sources (Grundy *et al*., 2004) also include elevated LDL-cholesterol as part of metabolic syndrome classification, but for the purpose of this study, the Triglyceride/HDL-ratio was used as a separate marker of health because it provides an estimate of dense LDL molecules (Da Luz *et al*., 2008).

Composite of health

A composite of health was calculated on SPSS using the IRS, CRI, Non-HDL, Trig/HDL-ratio and metabolic syndrome scores. The objective was to reduce the multiple health variables to 1 representative health variable. The inclusion of the metabolic syndrome score and the Trig/HDL-ratio into a composite of health also combine a more modern understanding of illness and coronary risk pathology with the comprehensive, but dated, Illness rating and CRI scales. Composite scores are particularly convenient when numerous instruments are used to attain a more comprehensive estimation of a diverse construct, such as health. Reducing the data to a composite score make it more manageable especially if the aim is to compare the relationships of more than 1 independent variable with the numerous representative measures of the dependent variable. A new variable is essentially created, which is a mathematical function of all the related variables. The methodology described by Logio *et al*. (2008) was used to calculate the composite score. Composite scores can be unit-weighted or regression-weighted. The unit-weighted approach, used in this study, is to either add all items together or calculating the average of each item. The regression-weighted approach uses a factor analysis. The researchers opted for the unit-weighted approach.

Functional capacity

Baseline physiological assessments of aerobic fitness were done using the YMCA cycle ergometer sub-maximal test protocol (ACSM, 2010). Heart rate was recorded with a heart rate monitor. Karvonen's formula (ACSM, 2010) was used to determine 80% of maximum heart rate (220 – age – RHR × training percentage + RHR). The ACSM (2010) metabolic and multistage equations were used to calculate each individual's relative predicted VO_{2max} and/or functional capacity in METs (VO_{2max} divided by 3.5).

Physical activity

Two measuring instruments were used to access participation in PA, namely the Baecke PA questionnaire (Baecke *et al*., 1982) and the index developed by Sharkey (1984).

By allocating the Borg scale numerical values to the practise requirements, intensity, duration and frequency, the Sharkey method (Sharkey, 1984) expresses participation in PA as an index by multiplying the values with each other. The Sharkey Index measures relative perceived intensity of training with a Likert-type scale where 1 equals light PA, such as fishing and walking, and 5 equal’s activity that incite sustained heavy breathing. The Baecke questionnaire also utilises the Likert scale scores for intensity (1=never sweat doing PA to 5=always sweating), duration (1=less than 5 minutes to 5=>45 minutes) and frequency

(1=never to 5=very often), to calculate absolute type scores for work, sport and leisure activity. The leisure index include walking and cycling for transportation purposes (work, school and during shopping). Philippaerts and Lefevre (1998) studied the reliability and validity of the Baecke Index against Doubly Labelled Water (DLW) and found that it provided both reliable and valid PA data.

Data analysis

The inter-relationships between the PA and cardiovascular fitness variables were investigated with partial correlations as part of the first aim of the study. The control variables were age, gender and body weight. This analysis provides information on the relative contributions of the various PA variables with cardiovascular fitness.

The contributions of the PA variables and cardiovascular fitness to health were assessed with a stepwise multiple regression analysis. The dependent variable was a composite of health. The independent variables were age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity and intensity. This analysis was used to compare the relative contributions of intensity of training, PA dose and MET to the variance of the composite of health. The R^2 change values provide information on the amount of variance explained by each variable entered. This analysis offers information for the first and second aims.

Two ANCOVAs were performed using the same control variables as in the partial correlations. The first ANCOVA was performed to assess the dependent and independent relationships of PA dose and intensity of training with all the health variables. Participants were placed into low, moderate and high intensity and PA dose groups based on the group distributions as determined with frequency tables. Those in the upper 30% of the group distribution were classed as high in terms of PA and intensity of training, while those in the bottom 30% were classed as low. The rest were placed in the moderate group. The cut-offs for intensity were 2.5 (n=104) and 4.6 (n=102) for the low and high groups, indicating a normal distribution since the number of respondents above and below the 30 and 70% percentiles were almost the same. The high and low grouping cut-offs for PA dose were 36.0 (n=86) and 63 (n=90) respectively, which also indicate a nearly normal distribution.

In the second ANCOVA, intensity of training and MET was used as independent variables and the composite of health as the dependent variable. The cut-off for the high and low MET groupings were <8.0 MET (n=76) and >9.99 (n=69) respectively. Eta^2 and Wilks Lambda scores were calculated to determine individual and combined contributions of the independent and control variables to the variances of the dependent variable. This analysis provides information relating to the 3rd study aim.

Log data transformation of the dependent variables was done to correct for slight positive skewness. The log transformed variables were checked again for normality and met skewness and standard error (SE) criteria of normality: CRI (skewness=0.343; SE=0.104); IRS (skewness= -0.531; SE=0.204); metabolic syndrome (skewness= -0.160; SE=0.054); Non-HDL (skewness= -0.262; SE=0.104); Trig/HDL-ratio (skewness=0.466; SE=0.204) and composite of health (skewness=0.231; SE=0.104).

RESULTS

Descriptive characteristics of participants

The average age of the 237 participants was 39.5 years. Almost 60% of this group were women (Table 1). The mean VO_{2max} of the participants was 31.4ml.kg^{-1} (8.97 MET x 3.5), which is a moderate level of cardiovascular fitness. Of the group, 32.1% (n=76) had a functional capacity lower than 8.0 MET, while 29.1% (n=69) had functional capacities higher than 10.0 MET. A Sharkey PA dose value of 45 equates to more or less 1000kcal.week^{-1} (Dreyer & Strydom, 1994). The group mean of 57.4, therefore, indicates a cohort of participants that was moderately physically active. A Sharkey dose value of 36.0 represents a kilocalorie expenditure of 450kcal.week^{-1}, while 63.0 equates to about 1500kcal.week^{-1} (Dreyer & Strydom, 1994). A total 36.3% (n=86) of the participants were below the 450kcal.week^{-1} cut-off and 37.9% (n=90) above the 1500kcal.week^{-1} cut-off.

TABLE 1. **DESCRIPTIVE CHARACTERISTICS OF PARTICIPANTS**

Variables	**Total (N=237)** Mean±SD	**Women (n=142)** Mean±SD	**Men (n=95)** Mean±SD
Age	39.50±12.10	40.20±12.00	35.20±12.00
Weight (kg)	79.30±18.90	73.20±15.80	87.30±19.90
Body Fat (%)	21.90±9.80	27.40±8.40	14.40±6.10
BMI	27.20±5.60	26.90±5.50	27.50±5.80
Health			
IRS	258.70±205.70	317.90±218.30	253.50±193.10
CRI	24.50±7.20	23.50±6.87	25.50±7.30
MS-score	1.72±1.10	1.57±1.10	1.95±1.13
Non-HDL	3.80±0.95	3.76±0.90	3.85±0.95
Trig/HDL-ratio	0.88±0.66	0.80±0.60	1.01±0.74
C-V capacity			
PWC_{170}	2.04±0.62	1.83±0.52	2.33±0.62
MET	8.97±2.21	8.33±2.05	9.83±2.16
Physical activity			
Sharkey index	57.40±47.29	53.50±48.70	64.90±44.70
Intensity	3.80±2.78	3.39±2.87	4.21±2.68
Duration	6.54±4.66	5.97±4.98	7.11±4.34
Frequency	5.62±3.90	5.38±4.39	5.87±3.41
Baecke index	2.48±0.58	2.35±0.56	2.60±0.59
Work activity	2.28±0.40	2.30±0.41	2.26±0.39
Sport activity	3.02±1.33	2.72±1.31	3.32±1.34
Leisure activity	2.14±0.57	2.04±0.55	2.23±0.58

IRS=Illness Rating Scale CRI=Coronary Risk Index BMI=Body Mass Index;
MS-score=Metabolic Syndrome score C-V capacity=Cardiovascular capacity

Relationships between physical activity and cardiovascular fitness variables

Partial correlations were calculated firstly, to determine the relationships between the measures of PA and cardiovascular fitness, while controlling for age, weight and gender (Table 2). The r^2, which provides information on shared variance and coefficient of determination, are indicated in brackets. The lowest r^2 was 0.6% (work activity with PWC_{170}) and the highest 20.3% (Baecke PA dose and sport activity with PWC_{170} and MET). This shows that the effect of PA and the cardiovascular fitness variables on health, as investigated in the ANCOVAs, are not confounded. It also provides information on which of the PA variables shows the most meaningful coefficient of determination to the variances of the cardiovascular fitness variables.

TABLE 2. **PARTIAL CORRELATIONS# OF PHYSICAL ACTIVITY WITH CARDIOVASCULAR FITNESS**

Physical activity measures	**PWC_{170}**	**METS**
Sharkey PAI	0.39* (15.2%)	0.39* (15.2%)
Intensity	0.37* (13.7%)	0.37* (13.7%)
Overall Baecke	0.45* (20.3%)	0.45* (20.3%)
Work activity	0.08 (00.6%)	0.09 (00.8%)
Sport activity	0.45* (20.3%)	0.45* (20.3%)
Leisure activity	0.27* (07.3%)	0.28* (07.8%)

Values in brackets: r^2 x 100 *=p<0.05 # Controlling for age, weight, gender

PA dose, as measured with the Baecke questionnaire, correlates slightly better (r=0.45 versus r=0.37) with cardiovascular capacity (PWC_{170} and MET), than relative perceived intensity of exercise (Table 2). The Baecke sport activities subscale (r^2 x 100= 20.3%) and the Sharkey intensity of training scale (r^2 x 100=13.7%), are markedly better contributors to the variance of MET than the other 2 Baecke subscales (work activity=0.8% and leisure activity=7.8%).

Physical activity and cardiovascular fitness as predictors of health

A stepwise multiple regression analysis was performed to compare the contributions of intensity of training and the other PA variables, as well as cardiovascular fitness to the variance of the composite of health. This analysis provides information on the overall theme of the study, namely the moderating effect of intensity of training on the relationships of PA dose and cardiovascular fitness to health. In total 10 independent variables (age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity and the Sharkey intensity scale), were used in this analysis. Only 6 of the variables (body weight, MET, Sharkey dose, intensity, work activity and leisure activity), were listed as contributors to the composite of health in the stepwise regression output. The major contributor was body weight (F=37.5; R^2=0.214; p=0.000).

The other significant contributors were MET (F=23.9; R^2=0.117; p=0.000), relative intensity of training (F=4.99; R^2=0.023; p=0.027) and Sharkey dose (F=4.04; R^2=0.019; p=0.046). Work activity and leisure activity were listed as non-significant contributors. In terms of the aims of the study, the important information gained from this analysis is that the relative intensity scale contributed slightly more (2.3%) to the variance of the composite of health than PA dose (1.9%), but markedly less than MET (11.7%). The 6 independent variables in Table 3 contributed as a group 38.7% to the variance of the composite of health.

TABLE 3. **STEPWISE MULTIPLE REGRESSION ANALYSIS TO PREDICT A COMPOSITE OF HEALTH**

Predictor variables	Multiple R	Multiple R^2	R^2 change	F-value	p-Value
Body weight	0.463	0.214	0.214	37.60	0.000
MET	0.575	0.331	0.117	23.90	0.000
Sharkey dose	0.592	0.350	0.019	4.04	0.046
Intensity	0.611	0.373	0.023	4.99	0.027
Work activity	0.616	0.379	0.006	1.39	0.239
Leisure activity	0.622	0.387	0.007	1.45	0.231

Note: No control variables were used in this analysis.

Dependent and independent relationships of intensity of training and physical activity dose with health

The individual and combined relationships of intensity of training and an overall PA score to cardiovascular fitness (METs) and measures of health was investigated with a ANCOVA. The covariates were age, gender and body weight.

TABLE 4. **RELATIONSHIPS OF OVERALL ACTIVITY AND INTENSITY OF TRAINING WITH MEASURES OF CARDIOVASCULAR FITNESS AND HEALTH: ANCOVA ANALYSIS**

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
MET	Gender	31.160	0.000	0.145	53.6%
	Age	16.106	0.000	0.081	
	Body weight	15.558	0.000	0.078	
	Intensity level	8.530	0.000	0.085	
	MET level	2.350	0.098	0.025	
	Combined	1.577	0.182	0.033	
	Overall model	14.388	0.000	0.464	
IRS	Gender	15.193	0.000	0.077	86.8%
	Age	0.046	0.831	0.000	
	Body weight	8.884	0.003	0.046	
	Intensity level	2.029	0.134	0.022	
	MET level	1.008	0.367	0.011	
	Combined	0.818	0.515	0.018	
	Overall model	2.528	0.005	0.132	

TABLE 4. **(cont.)**

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
CRI	Gender	0.001	0.970	0.000	56.7%
	Age	42.349	0.000	0.188	
	Body weight	48.782	0.000	0.210	
	Intensity level	1.516	0.222	0.016	
	MET level	0.676	0.510	0.007	
	Combined	0.301	0.877	0.007	
	Overall model	12.705	0.000	0.433	
Non-HDL	Gender	0.463	0.498	0.004	82.6%
	Age	7.793	0.006	0.057	
	Body weight	8.253	0.005	0.061	
	Intensity level	1.218	0.299	0.019	
	MET level	0.115	0.892	0.002	
	Combined	0.857	0.492	0.026	
	Overall model	2.455	0.008	0.174	
Trig/HDL-ratio	Gender	0.048	0.827	0.000	80.9%
	Age	6.175	0.014	0.046	
	Body weight	18.322	0.000	0.125	
	Intensity level	0.569	0.568	0.009	
	MET level	0.717	0.490	0.011	
	Combined	0.491	0.742	0.015	
	Overall model	2.750	0.003	0.191	
Metabolic syndrome score	Gender	0.175	0.677	0.001	67.1%
	Age	23.537	0.000	0.155	
	Body weight	19.658	0.000	0.133	
	Intensity level	0.770	0.465	0.012	
	MET level	1.542	0.218	0.024	
	Combined	0.180	0.948	0.006	
	Overall model	5.693	0.000	0.329	
Composite health score	Gender	0.455	0.501	0.004	56.8%
	Age	32.549	0.000	0.203	
	Body weight	49.242	0.000	0.278	
	Intensity level	1.135	0.325	0.017	
	MET level	0.228	0.797	0.004	
	Combined	0.106	0.980	0.003	
	Overall model	8.833	0.000	0.432	

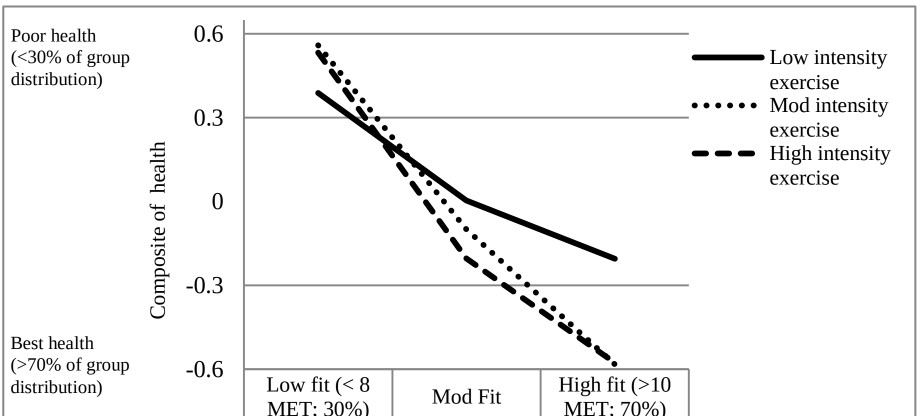
The F-ratio, p-values and ETA^2 values of each of the independent variables, the combined variables and the control variables are presented in Table 4. Intensity of training contributed more to the variance of MET (8.5% versus 2.5%), IRS (2.2% versus 1.1%), CRI (1.6% versus 0.7%), Non-HDL (1.9% versus 0.2%) and the composite health score (1.7% versus 0.4%), than the overall activity score. The contribution of intensity was statistically significant (p=0.000) only in the case of MET. PA dose showed a marginally higher contribution to the variance of Trig/HDL-ratio (1.1% versus 0.9%) than intensity of training. Body weight was the only variable that showed a statistically significant relationship with all 6 dependent variables in Table 4.

Dependent and independent relationships of intensity of training and cardiovascular fitness with a composite of health

In order to assess the moderating effect of intensity of training on the fitness-health relationship, a second ANCOVA was performed. The composite of health showed very similar relationships with the PA measures as the other health variables in the first ANCOVA. In order to condense and focus the discussion only the composite of health was used in the second ANCOVA (Table 5).

TABLE 5. **RELATIONSHIPS OF METS AND INTENSITY OF TRAINING WITH A COMPOSITE HEALTH SCORE: ANCOVA ANALYSIS**

Variables	**F-ratio**	**p-Values**	**Eta^2**	**Wilks Lambda**
Gender	2.265	0.135	0.017	64.0%
Age	0.048	0.827	0.000	
Body weight	23.301	0.000	0.154	
Intensity level	0.765	0.470	0.012	
MET level	6.753	0.002	0.095	
Combined	0.346	0.847	0.011	
Overall model	6.559	0.000	0.360	



	Low fit (< 8 MET; 30%)	Mod Fit	High fit (>10 MET; 70%)
Low intensity exercise	0.388	0.003	-0.205
Mod intensity exercise	0.559	-0.099	-0.583
High intensity exercise	0.533	-0.204	-0.577

FIGURE 1. **ASSOCIATION BETWEEN PERCEIVED INTENSITY OF TRAINING AND COMPOSITE OF HEALTH STRATIFIED BY INTENSITY OF TRAINING**

The control variables were age, gender and body weight. Body weight (F=23.301; p=0.000) and MET (F=6.752; p=0.002) were the only statistically significant contributors to the variance of the composite health score in this analysis. Cardiovascular fitness (MET) contributed 9.5% (p=0.002) to the variance of the composite health score in comparison to the non-significant (p=0.470), 1.2% contribution of intensity of training.

The results of the ANCOVA reported in Table 5 are illustrated schematically in Figure 1. It reveals that moderate and high perceived intensity of training do not coincide with better health in the low fitness group (<8 MET). Those classified as low fit had mean composite health scores in the bottom 30% of the group distribution irrespective of level of participation in PA. In contrast, a downward trend can be observed in the low, moderate and high intensity groups in correspondence with level of cardiovascular fitness. As fitness increases the composite health score decreases, which indicates better health. The fitness-health improvements are nevertheless markedly steeper in the moderate and high perceived intensity cohorts (109.8% and 108.3%), as compared to the low intensity cohort (52.8%).

DISCUSSION

Figure 2 provides an illustration or model of the interactions between PA, fitness and health that is under scrutiny in this study. The model indicates that A (PA) leads to B (physical fitness) and that both A and B lead to C (Health). The model also positions that A and B do not necessarily influence each other's relationships with C.

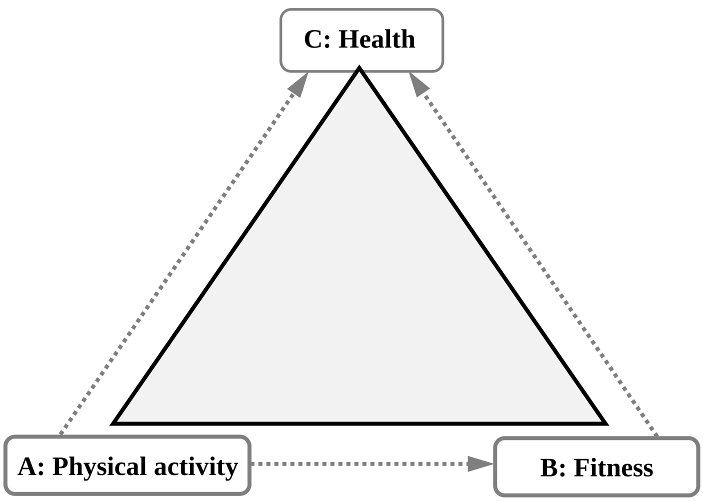


FIGURE 2. **MODEL OF PHYSICAL ACTIVITY, FITNESS AND HEALTH INTER-RELATIONSHIPS**

The scientific angle of the present study is that it is more appropriate to test the interactions between fitness, PA and health with a relative measure of perceived intensity as opposed to an absolute measure of PA. In short, the moderating impact of a relative measure of perceived intensity of training on the AB, AC and BC relationships in an apparently healthy population were investigated.

More specifically, the aims of this study were to determine whether relative perceived intensity of training moderates the PA-health (AC-line in Figure 2), PA-fitness (AB-line) and fitness-health (BC-line) relationships. The results indicate that perceived intensity of training had marginal moderating effects on the PA-health (AC) and the PA-fitness (AB) relationships. Perceived intensity of training had no moderating effect on the cardiovascular fitness-health (BC) relationship in the low fitness group and small moderating effects in the moderate and high fitness groups. The contribution of the measures of PA condenses to negligently small units in the presence of moderate and high levels of cardiovascular fitness.

Intensity as moderator of the physical activity-health (AC) relationship

The IPAQ questionnaire is widely considered the gold-standard PA questionnaire. The IPAQ questionnaire classifies all activity as either low, moderate or vigorous and not on a relative intensity continuum like the Borg Perceived Exertion and Pain Scale (RPE). Metabolic equivalents for walking and activities perceived to be moderate and vigorous are multiplied by days and minutes in the process of calculating MET/minute/week scores. In this way, job, transportation, domestic and sport/recreation PA's are expressed in absolute terms as MET/minutes/week (IPAQ, 2005). Defining intensity using an absolute scale in METs may be limited because it neglects variations in physical fitness.

In terms of the aims of the current study, the IPAQ scores were consequently considered 'contaminated' by fitness level, as well as by duration and frequency of training. What was needed for this study was a measure of relative perceived intensity and not an absolute PA score. Consequently, a relative intensity index developed by Sharkey (1984) was utilised, which has a Likert-like format, like the Borg RPE scale.

The Borg RPE Scale (Borg, 1998), is commonly used during exercise stress testing. Good correlations exist between ratings on this scale and heart rate (r=0.80 to 0.90), during graded exercise testing (Borg, 1998; Lee *et al*., 2003). Lee *et al*. (2003) used the Borg scale to rate exertion levels of habitual physical exercise of 7337 men. Participants were asked, "When you are exercising in your usual fashion, how would you rate your level of exertion (degree of effort)?" Men responded using a scale ranging from 0 ("nothing at all") to 10 ("maximal"). They found a dose-response relation with greater decrements in CHD rates at higher relative perceived intensities. This applied even to men not fulfilling current recommendations for PA. On the other hand, the absolute intensity of PA did not perform as well in distinguishing CHD risk groups (Lee *et al*., 2003).

Relative perceived intensity of training contributes more to the variances of virtually all the measures of health (IRS, CRI, Non-HDL and a composite of health), than the absolute PA scores (Table 4). The exceptions were the metabolic syndrome score (2.4% versus 1.2%) and the Trig/HDL-ratio (1.1% versus 0.9%).

Intensity as moderator of the physical activity dose-fitness (AB) relationship

A marginal tendency seemed to exist in the data that perceived intensity moderates of the PA dose-fitness (AB) relationship. The largest coefficient of determination (r^2) value was 20.3% (Table 2), indicating that, in this population, cardiovascular capacity (MET) is not an exclusive product of participation in physical exercise. Research on genetic determination of cardiovascular fitness indicates that genes account for 40 to 50% of individual variation in VO_{2max} (Bouchard *et al*., 1999). Cardiovascular fitness is clearly not an exclusive product of PA. Therefore, it is unrealistic to expect close to perfect correlations between measures of PA and cardiovascular fitness. High cardiovascular fitness is an indication of a highly integrated and well-functioning oxygen transport system free of pathological conditions. Genetics, underlying pathology, body composition, type of training/fitness testing can all influence how well PA patterns reflect cardiovascular status. The current data support the idea that fitness and PA (even if of high intensity), are separate entities that should be treated as separate risk factors. Maybe fitness status assessment should play an integral part in the cardiovascular risk paradigm.

In terms of measuring/assessing PA, the Sharkey intensity index did not excel as an outstanding predictor of fitness in this study. This was a slightly different outcome from what was expected and might be because the Sharkey relative intensity scale (stretching from 1 for light to 5 for sustained heavy breathing), has a ceiling effect. The intensity choices provided might not be broad enough to distinguish with apt exactitude between levels of intensity.

Paffenbarger *et al*. (1993) compared the average weekly exercise records of 107 women and 457 men over six months before they completed a maximal exercise test on a treadmill. They found correlations ranging from r=0.66 to r=0.83 across groups of younger and older men and women. Dreyer *et al*. (2012) reported a correlation of r=0.65 between intensity of physical training and change in VO_{2max} in clients that completed a 10-week exercise intervention program. Both these studies scored activity with the Cooper Clinic point system that corrects for intensity in the sense that the overall score are adjusted according to the time it takes to complete set workouts. The Cooper system adjustment for time is different from the IPAQ adjustments. The IPAQ multiply the vigorous days with activity minutes. The consequence is that it adjusts negatively for speed, whereby a higher score is attained if the perceived 'vigorous' run is slower. In contrast, the Cooper points system adjusts positively for speed by achieving a higher score if it takes fewer minutes to complete a set task/run/distance. The above findings support the idea that a more precise assessment of intensity might increase the fitness predictive qualities of PA questionnaires.

Helmerhorst *et al*. (2012) did a systematic review of reliability and objective criterion-related validity of PA questionnaires. They concluded that the validity of PA questionnaires was moderate at best. They emphasise the importance of accurate assessment of intensity levels as part of improving the validity of PA questionnaires. Scott *et al*. (2013) published a guide to the assessment of PA and stated that there is no single best instrument appropriate for every situation. It was against this backdrop that the Sharkey intensity index was trailed in the current study. The results of this study indicate that it lacks precision as a predictor of fitness, but not more so than the Baecke questionnaire, which is one of the better PA questionnaires, according to Helmerhorst *et al*. (2012).

Intensity as moderator of the fitness-health (BC) relationship

Intensity of training faded as a contributor to the composite health score when cardiovascular fitness (expressed as MET), was included as a predictor variable. The same applied to duration, frequency, work, sport and leisure activity measures. Therefore, physical exercise (whether of perceived high intensity and of long duration and/or at high frequency), did not equate to better health in the presence of low cardiovascular fitness in this analysis (Table 3).

The fact that the composite of health dropped by 52.8% across the fitness groups in the low-intensity group (Figure 1), indicates that fitness has health benefits independent of perceived intensity of exercise. A steeper downward trend across the fitness groups in the moderate and high perceived exercise intensity groups (109.8 and 108.3% respectively, versus 52.8% in the low-intensity group), exist. It suggests that perceived intensity of training has a positive effect on the cardiovascular fitness-health (BC) relationship. Similarly, Williams (2001) reported a 60% decline in risk for cardiovascular disease from the least-fit to the most-fit, in contrast to a 30% decline in risk from the least-active to most-active.

That high-intensity exercise leads to greater fitness benefits (as compared to low and moderate intensity exercise), is not a new concept. What is new is the increasing awareness of how important intensity of training is in the case of health and rehabilitation. Kemi and Wisløff (2010) suggest that a threshold of intensity may exist for improving the heart's mechanical efficiency. In a multivariable meta-regression analysis, Uddin *et al*. (2015) found only exercise intervention intensity to be significantly associated with VO_{2max} ($P = 0.04$) in patients with coronary heart disease and heart failure. In terms of study limitations, the cross-sectional design of the present study averts cause and effect conclusions. The study cohort also presents a relatively healthy group of adults ≥20 years. A similar study on individuals with co-morbidities is required. Future research could also benefit from using broader relative intensity scales and accelerometers.

PRACTICAL IMPLICATIONS

The practical implications of the findings of this study are that PA and cardiovascular fitness should be considered partly distinct components of health. Poor fitness and physical inactivity should be considered separate and inter-related risk factors. The findings leave the impression that the use of relative measures of intensity of training might positively affect the predictive (health and fitness) accuracy of PA questionnaires. Data from the current study and the literature quoted confirm that exercise of higher perceived intensity equates with better health outcomes. However, high-intensity exercise did not parallel with better health in the absence of moderate and high levels of fitness. Therefore, the data could also indicate that exercise for health needs to be of sufficient intensity to improve levels of cardiovascular fitness (Williams, 2001; Franklin, 2007; Kemi & Wisløff, 2010; Tjønna *et al*., 2013; DaFina *et al*., 2015). Rhen *et al*. (2013:5) states in this regard: "The question today is not whether physical activity per se has beneficial effects. The question is how to attain a sufficient level of high-intensity physical activity in all strata of the population."

CONCLUSIONS

Ultimately, cardiovascular fitness emerged as a potent marker of health in this study. Physical exercise on the other hand did not equate with better health in the absence of at least reasonable levels of fitness in this cross-sectional study of a selection of the workforce in the Manawatu region in New Zealand.

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Prof Lukas Dreyer: Universal College of Learning, Palmerston North, U-kinetics; 62 Grey Street; Palmerston North, Manawatu, New Zealand. Tel.: 06 354 0684, E-mail: l.dreyer@ucol.ac.nz

(Subject Editor: Me Kasha Dickie)